



**PHENIX results for J/ψ p_T
and rapidity dependence in
heavy ion collisions**

Andrew Glenn

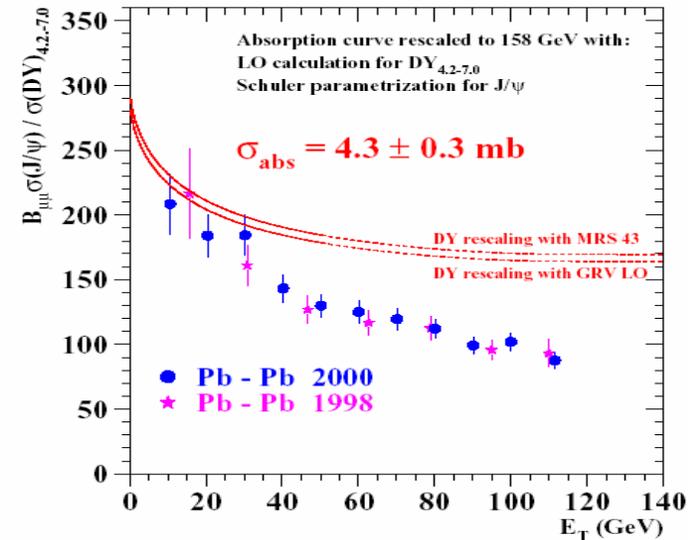
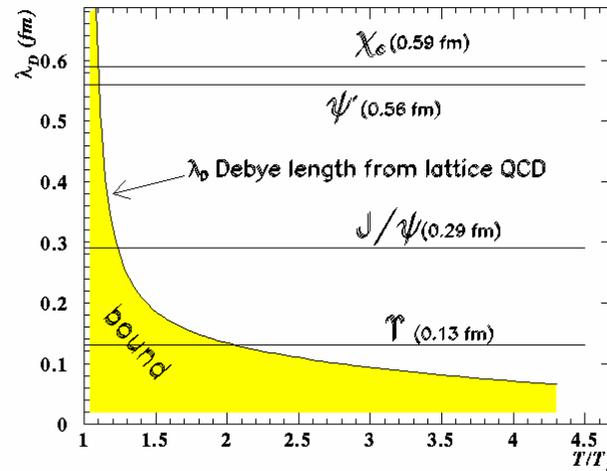
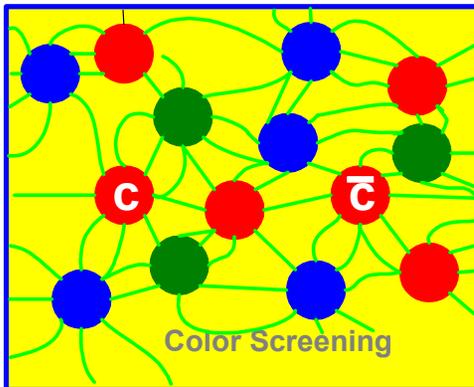


University of Colorado
for the PHENIX collaboration
November 18, 2006



Motivation

- A quark gluon plasma has been predicted to suppress J/Ψ production
- Interesting suppression patterns have been observed at lower energies at the CERN SPS
- Rapidity and transverse momentum provide additional model constraints



The PHENIX detector

Central arms:

hadrons, photons, electrons

$$J/\Psi \rightarrow e^+e^-$$

$$|y| < 0.35$$

$$\Delta\phi = \pi$$

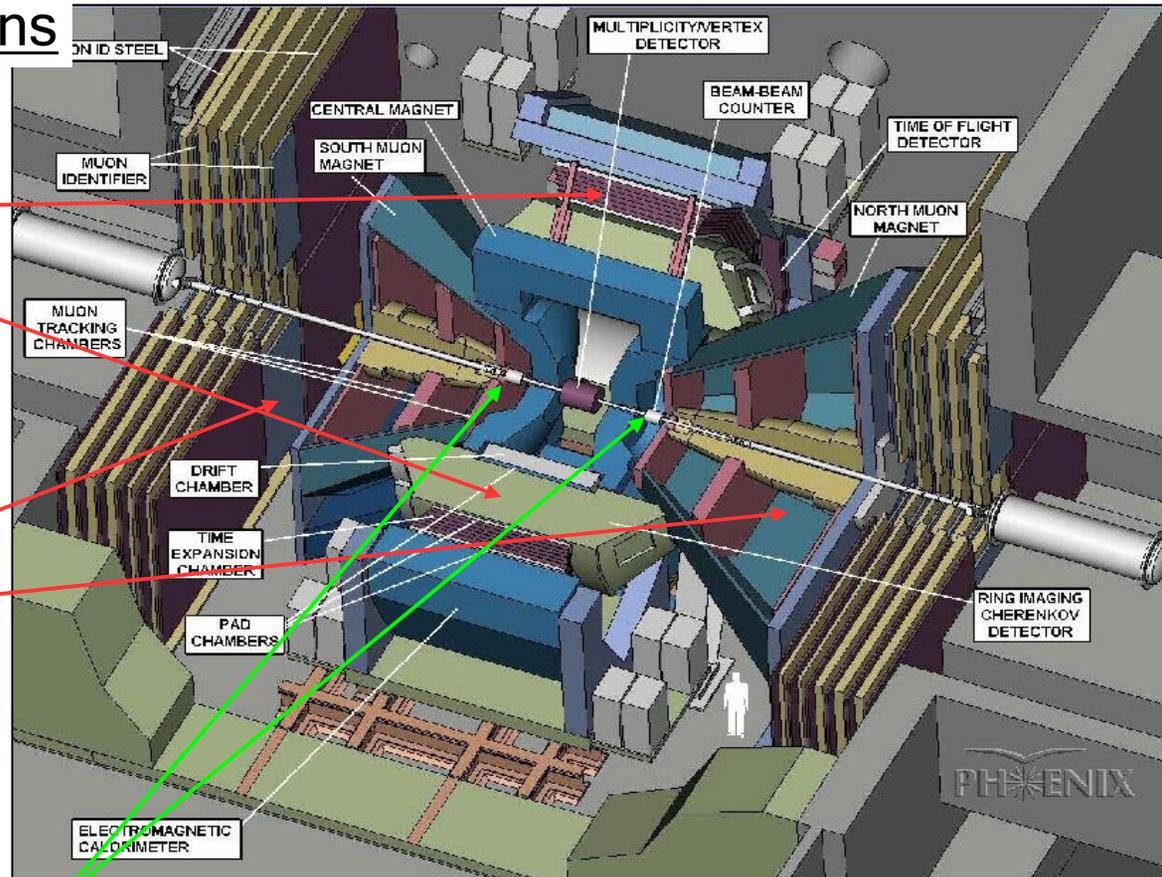
Muon arms:

muons at forward rapidity

$$J/\Psi \rightarrow \mu^+\mu^-$$

$$1.2 < |y| < 2.2$$

$$\Delta\phi = 2\pi$$



Centrality measurement:

We use beam beam counters together with zero degree calorimeters

Centrality is mapped to N_{part} (N_{col}) using Glauber model

PHENIX J/ ψ Measurements

Year	Ions	$\sqrt{s_{NN}}$	Luminosity	Status	Approx. J/ ψ ($ee + \mu\mu$)
2001	Au+Au	200 GeV	24 μb^{-1}	Central	13 + 0 [1]
2002	p+p	200 GeV	0.15 pb^{-1}	+ 1 muon arm	46 + 66 [2]
2002	d+Au	200 GeV	2.74 nb^{-1}	Central	360 + 1200 [3]
2003	p+p	200 GeV	0.35 pb^{-1}	+ 2 muon arms	130 + 450 [3]
2004	Au+Au	200 GeV	240 μb^{-1}	Final analysis	1000 + 4500 [4]
	Au+Au	63 GeV	9.1 μb^{-1}		
	p+p	200 GeV	324 nb^{-1}		
2005	Cu+Cu	200 GeV	4.8 nb^{-1}	Preliminary	2300 + 9000 [5]
	Cu+Cu	63 GeV	190 mb^{-1}	Preliminary	150
	p+p	200 GeV	3.8 pb^{-1}	Final	1500 + 8000 [6]

[1] [PRL92 \(2004\) 051802](#)

[2] [PRC69 \(2004\) 014901](#)

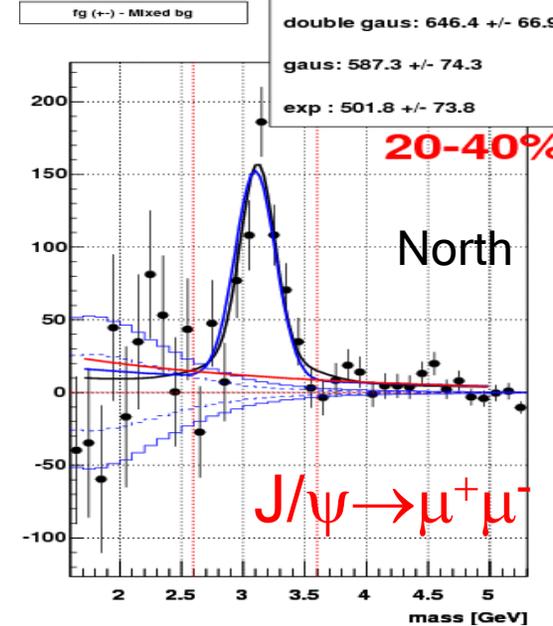
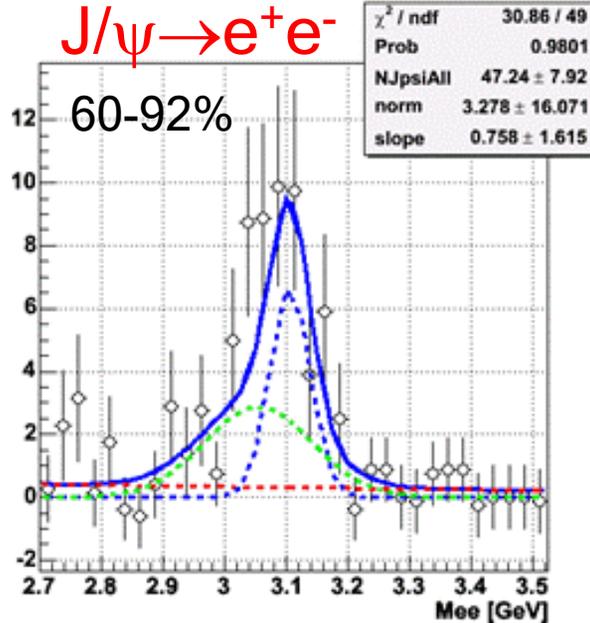
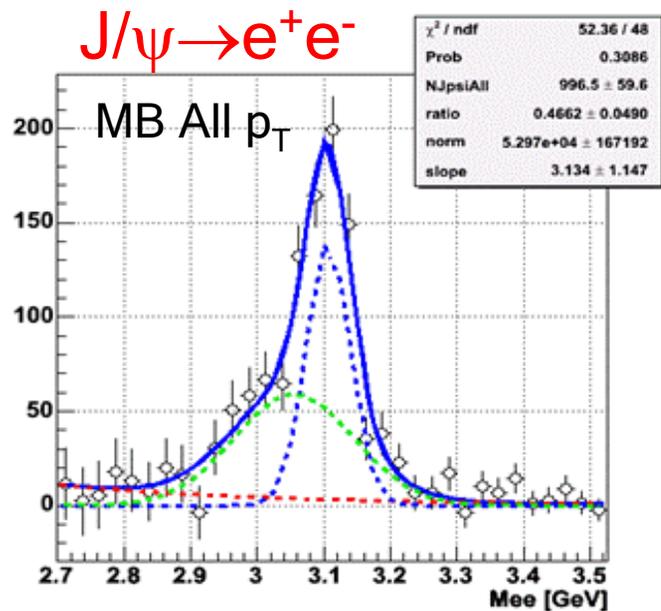
[3] [PRL96 \(2006\) 012304](#)

[4] [nucl-ex/0611020](#)
submitted to PRL

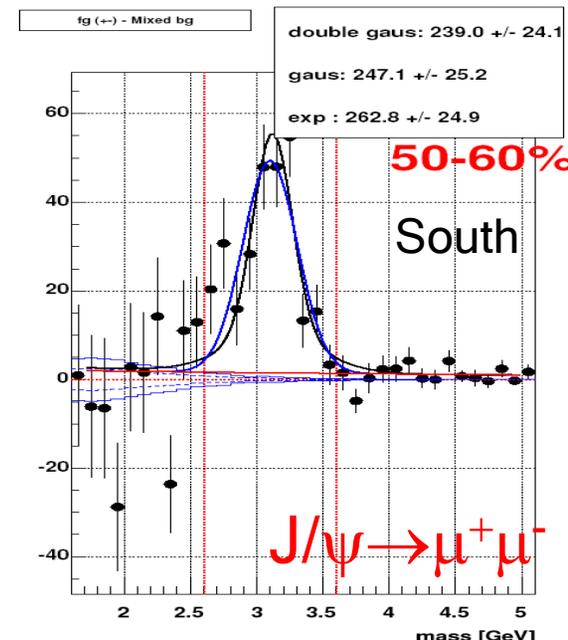
[5] QM05, [nucl-ex/0510051](#)

[6] [hep-ex/0611020](#)
submitted to PRL

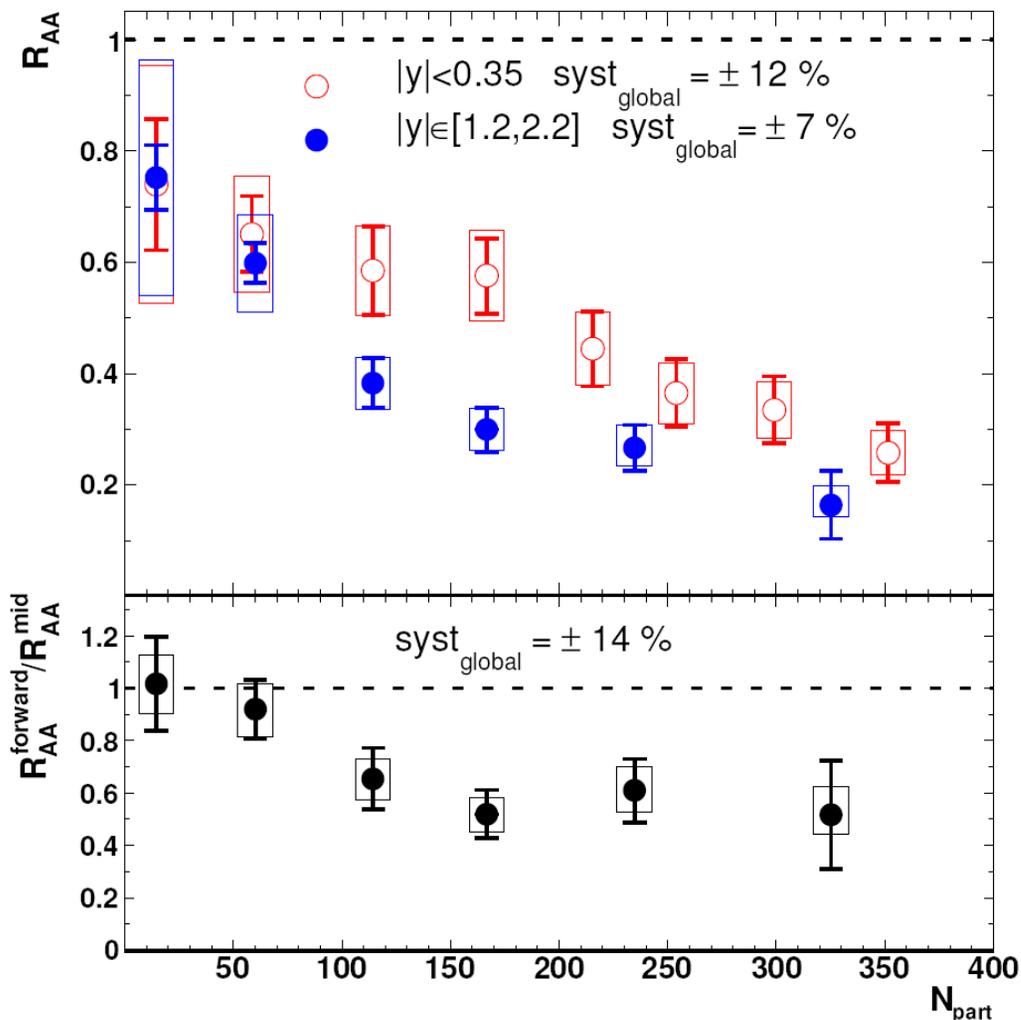
J/ψ Signal in Au+Au



- Background subtracted using event mixing
- Number of J/ψ calculated fits exponential/gaussian combinations.
- The mixed mixed event background is varied to estimate the systematics
- Cu+Cu signal is similar to Au+Au peripheral, with much larger statistics



Nuclear Modification



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$$R_{AA} = \frac{d^3N_{J/\psi}^{AuAu}/dp^3}{d^3N_{J/\psi}^{pp}/dp^3 \times \langle N_{coll} \rangle}$$

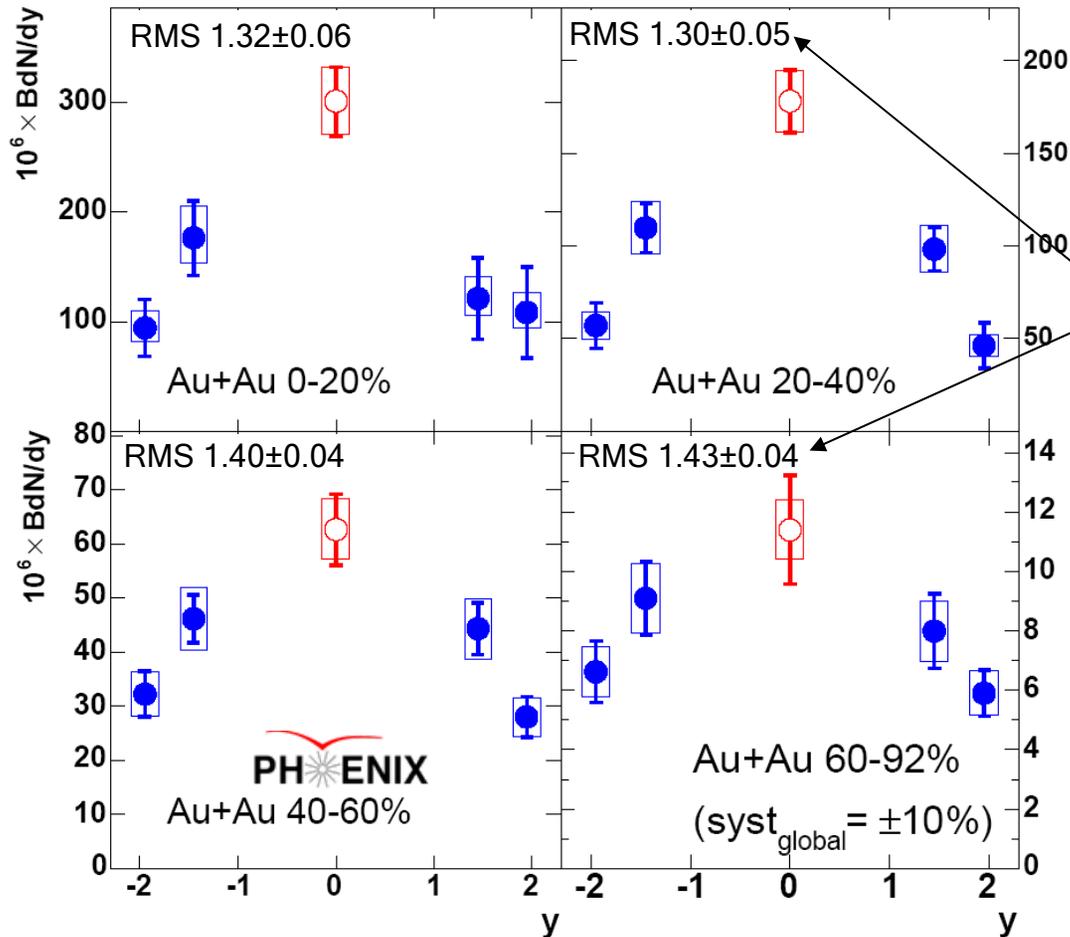
You will hear about the details of centrality dependence from Taku Gunji later in this session.

- Rapidity dependence for non-peripheral collisions
- Not clear in preliminary data
- More suppression at forward rapidity

Rapidity Dependence

PHENIX has measured y dependence in p+p.

Details and finer binning from Abby Bickley later in the session



Appears to be a slight narrowing of the rapidity distribution with respect to p+p.

We use R_{AA} to be quantitative.

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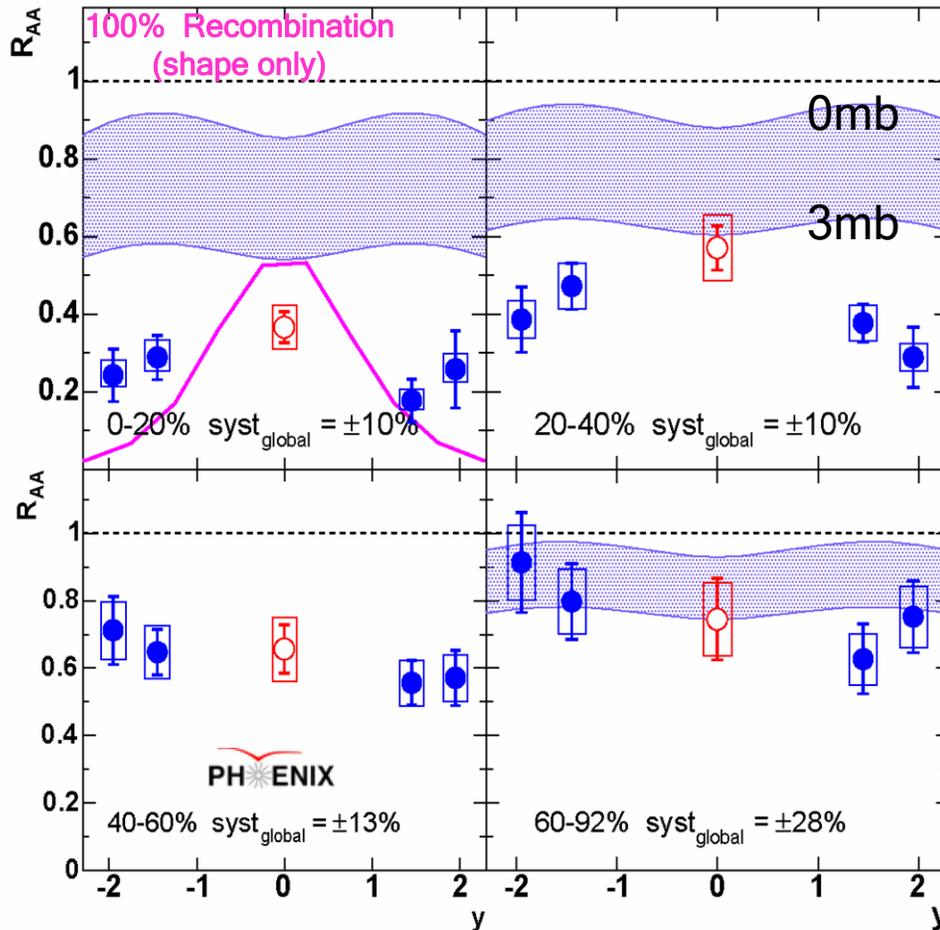
November 18, 2006

Quark Matter 2006

$R_{AA}(y)$

R. Vogt nucl-th/0507027 ?
EKS

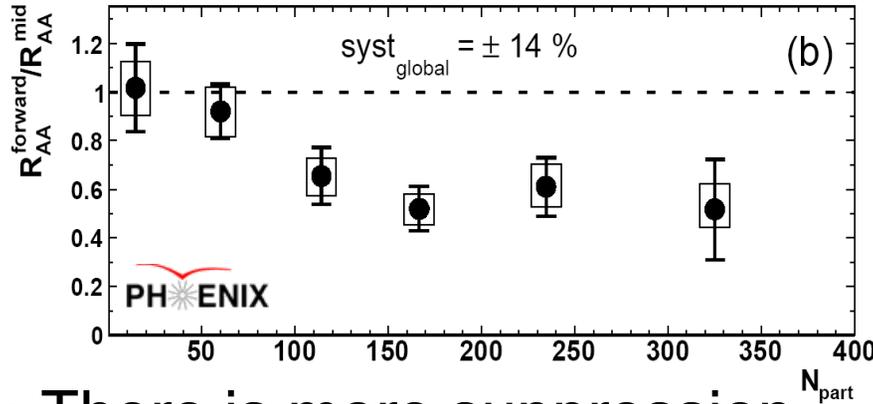
R. L. Thews, M. L. Mangano
Phys.Rev. C73 (2006) 014904



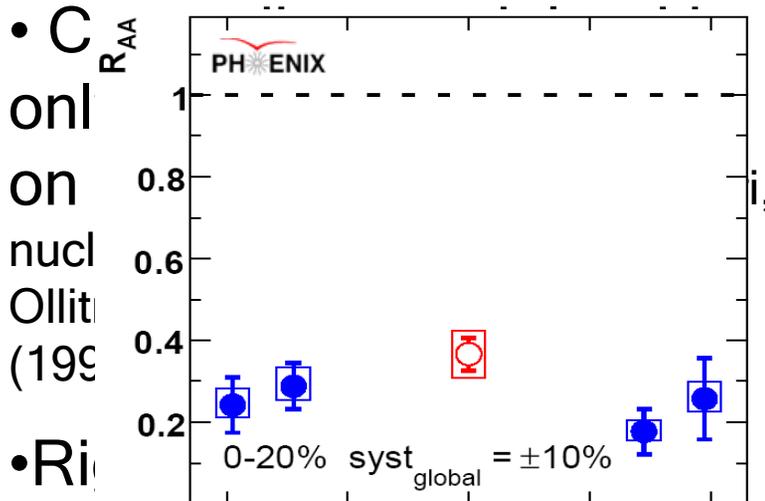
- More suppression in central events than cold nuclear matter calculations would suggest.
- Not as much narrowing as simple 100% recombination scenario
- Dependent on inputs like charm rapidity distribution

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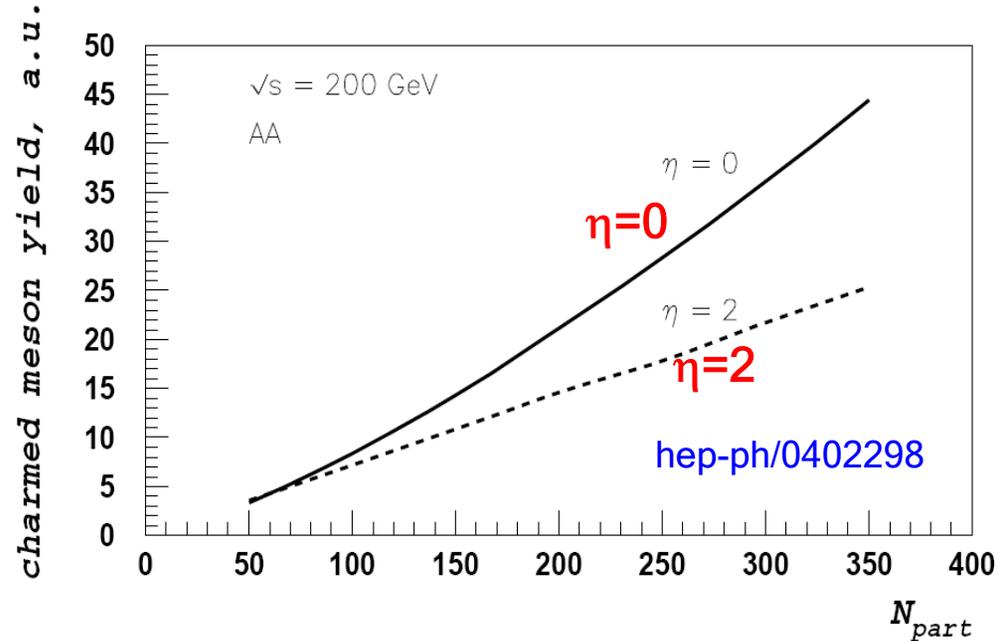
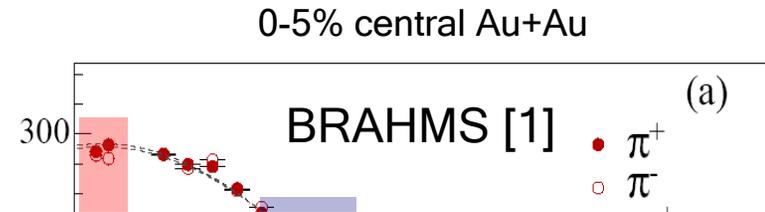
Suppression & density



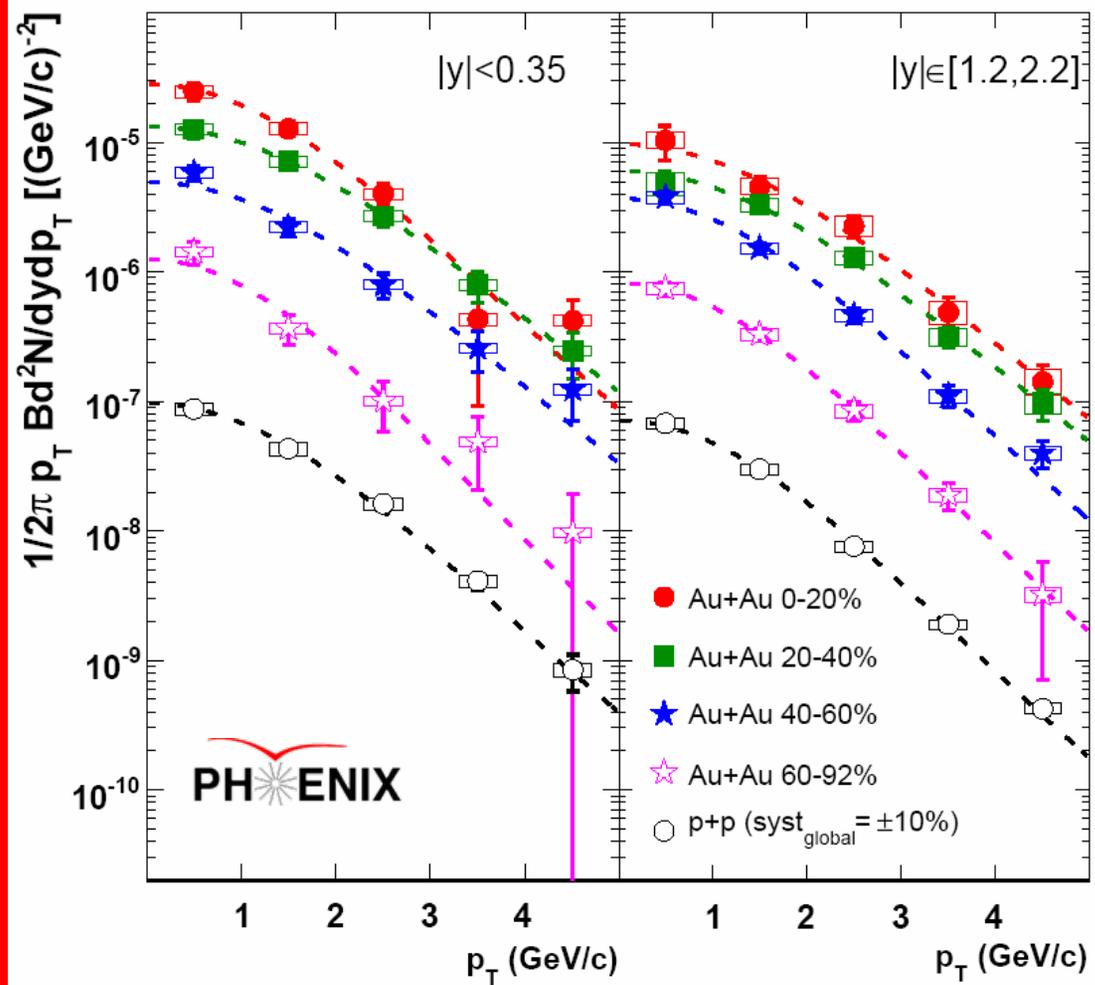
- There is more suppression at forward rapidity.



- R_{AA} on non-nucleon constituents (199)
- R_{AA} recombination and/or color glass



Transverse Momentum



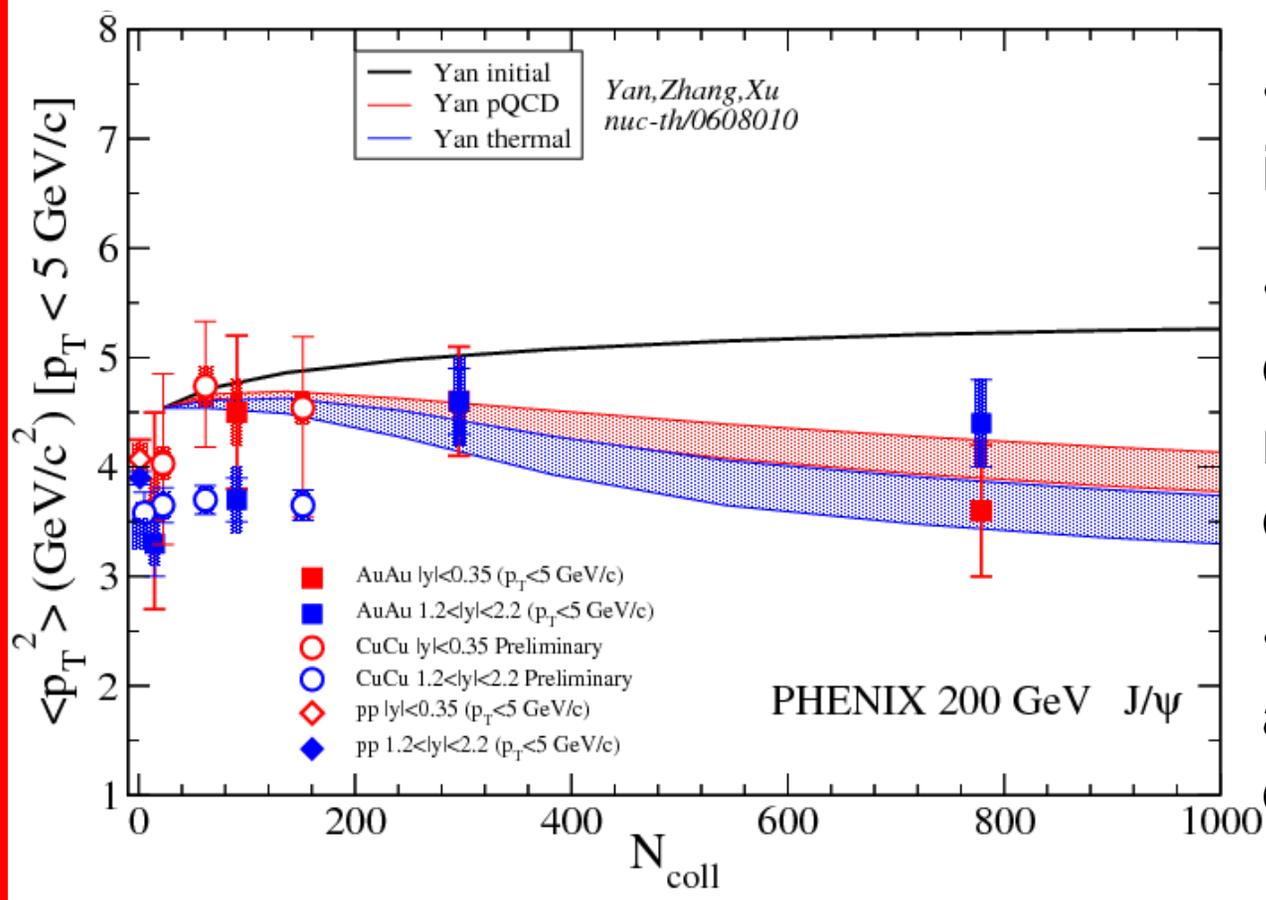
Transverse momentum measured out to 5 GeV/c

Used to calculate $\langle p_T^2 \rangle$, which is predicted to be sensitive to various physics processes (recombination component for instance)

We only calculate $\langle p_T^2 \rangle$ directly using the data over the measured range (no fit or extrapolation to infinite p_T)

nucl-ex/0611020 submitted to PRL

Mean p_T^2



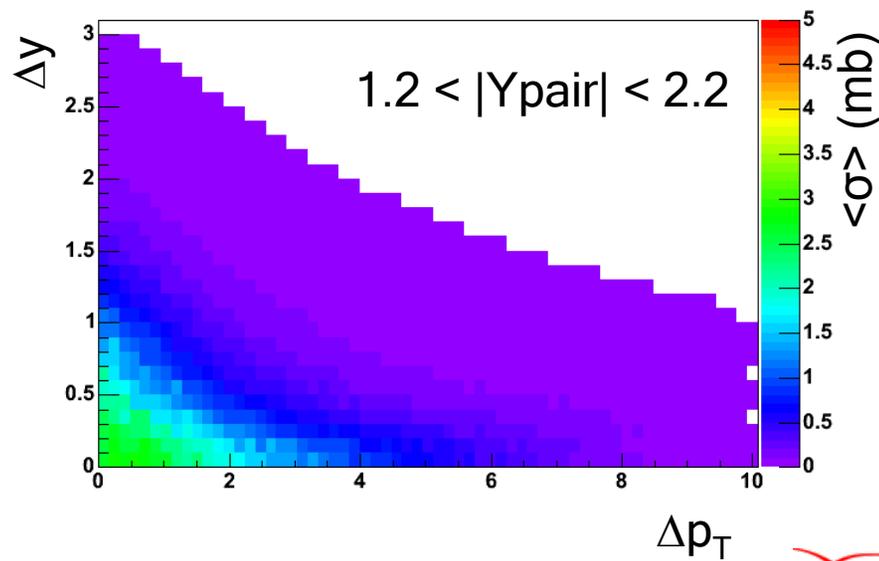
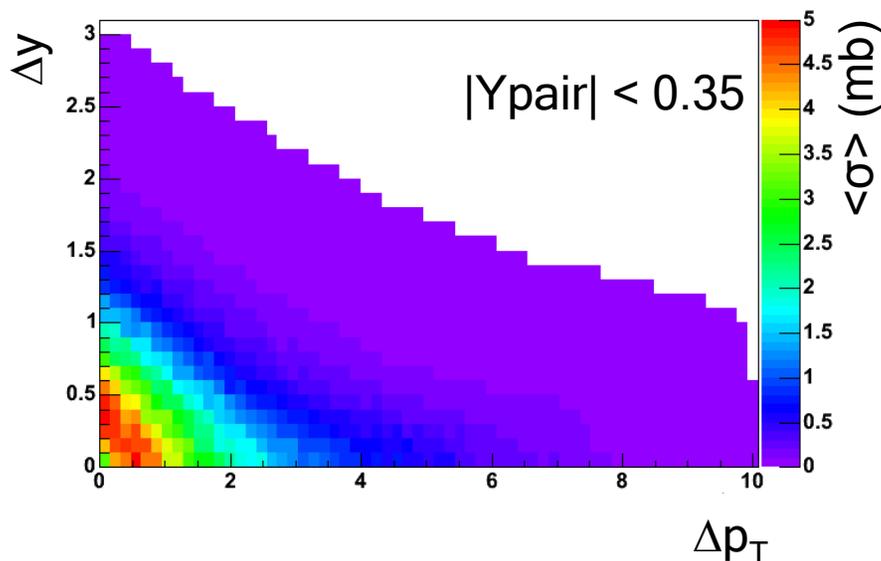
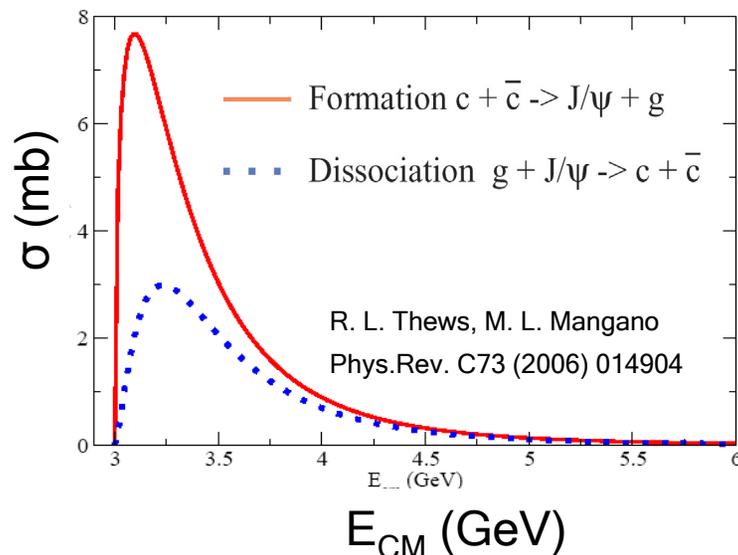
- Moderate if any increase
- Qualitatively consistent with a recombination component
- But this is not nearly as dramatic in some calculations

Note that forward p+p $\langle p_T^2 \rangle$ is larger than previously reported (see A. Bickley's talk). The forward d+Au $\langle p_T^2 \rangle$ is being revisited. These are important inputs to models such as Thews et al.

Recombination Aside

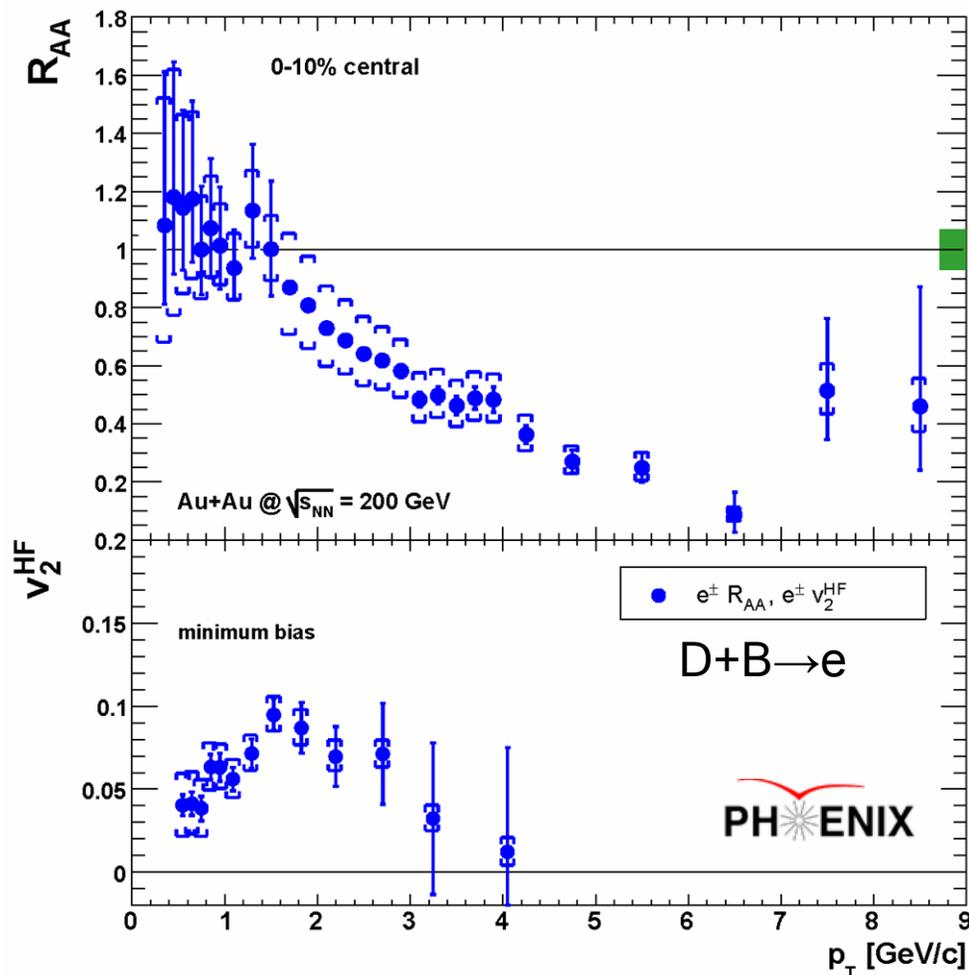
- Throw $m_c = 1.5$ GeV/c pairs flat in η , ϕ , and p_T
- Assign sigma based on E_{CM}
- Find average cross-section for bins of Δy and Δp_T between the quarks
- Most recombination in $\Delta y < 0.5$ and $\Delta p_T < 1$ GeV/c
- Less recombination at forward rapidity

OEM calculation



Heavy Quarks in Medium

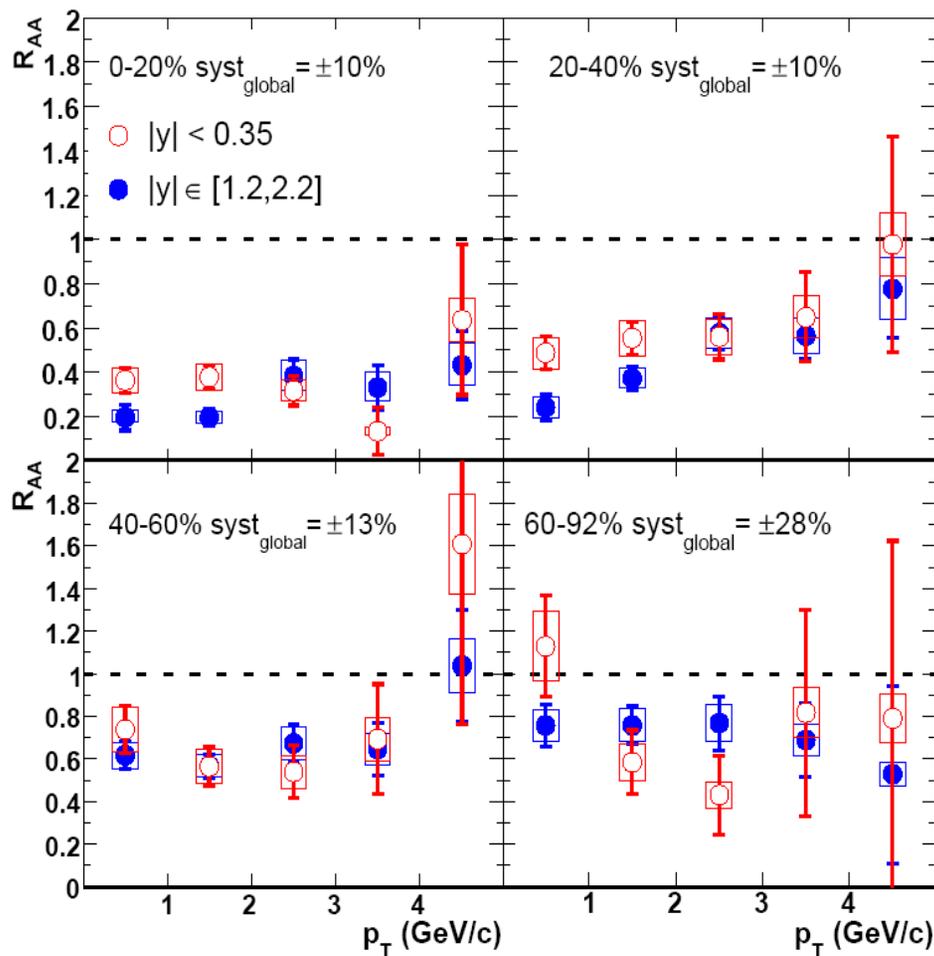
nucl-ex/0611018 submitted to PRL



- We know heavy quarks interact with the medium.
- Recombination is one of the leading candidates to explain the level of J/Ψ suppression at RHIC.
- Doesn't this cause a depleted recombination component for high p_T J/Ψ ?

New PHENIX reaction plane detector will help with J/Ψ v_2 in next Au+Au run

$R_{AA}(p_T)$



- Suppression trend is similar for forward and mid rapidity.
- Suppression consistent with flat.
- High p_T heavy flavor electron suppression + large recombination component = larger R_{AA} at low p_T than high p_T (how high?)
 - Not the only idea that predicts more suppression at high p_T (hep-ph/0607062 “Hot Wind” private communication)

nucl-ex/0611020 submitted to PRL

Summary & Conclusion

- Significant J/Ψ suppression up to $R_{AA} \sim 0.3$
- Stronger suppression observed at forward rapidity than mid rapidity.
 - Larger dN/dy (local density) \neq Larger J/Ψ suppression
- J/Ψ measured out to 5 GeV/c in p_T
 - $\langle p_T^2 \rangle$ has moderate, if any, increase with N_{coll}
 - R_{AA} consistent with flat in p_T
- These data will help constrain models

Some Related Posters

- Poster 63 **S.X. Oda**
Measurement of J/ψ mesons via di-electrons in Cu+Cu collisions at RHIC-PHENIX
- POSTER 163 **C. Silvestre**
A new alignment method for PHENIX muon arms
- POSTER 64 **A. Glenn**
PHENIX J/ψ results at forward rapidity in $\sqrt{s_{NN}} = 200$ GeV Au+Au and Cu+Cu collisions
Pick Up a Copy of nucl-ex/0611020

- Brazil** University of São Paulo, São Paulo
- China** Academia Sinica, Taipei, Taiwan
China Institute of Atomic Energy, Beijing
Peking University, Beijing
- France** LPC, University de Clermont-Ferrand, Clermont-Ferrand
Dapnia, CEA Saclay, Gif-sur-Yvette
IPN-Orsay, Université Paris Sud, CNRS-IN2P3, Orsay
LLR, École Polytechnique, CNRS-IN2P3, Palaiseau
SUBATECH, École des Mines at Nantes, Nantes
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Debrecen University, Debrecen
Eötvös Loránd University (ELTE), Budapest
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- Israel** Weizmann Institute, Rehovot
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Hiroshima University, Higashi-Hiroshima
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Korea University, Seoul
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- Russia** Institute of High Energy Physics, Protovino
Joint Institute for Nuclear Research, Dubna
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PNPI, St. Petersburg Nuclear Physics Institute, St. Petersburg
St. Petersburg State Technical University, St. Petersburg
- Sweden** Lund University, Lund



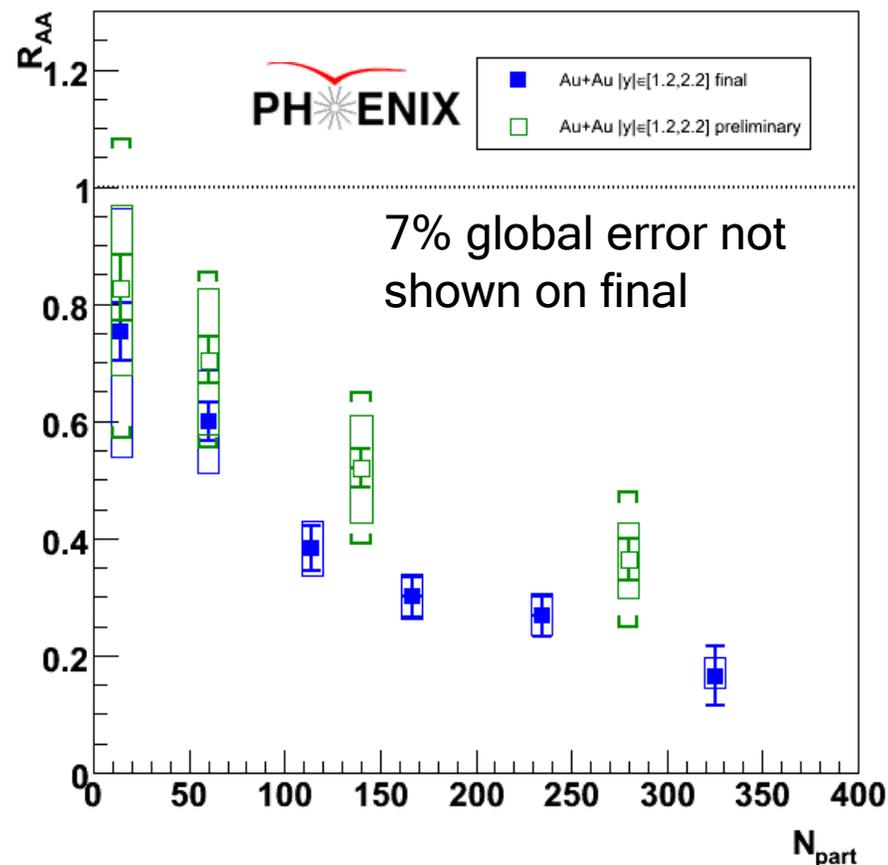
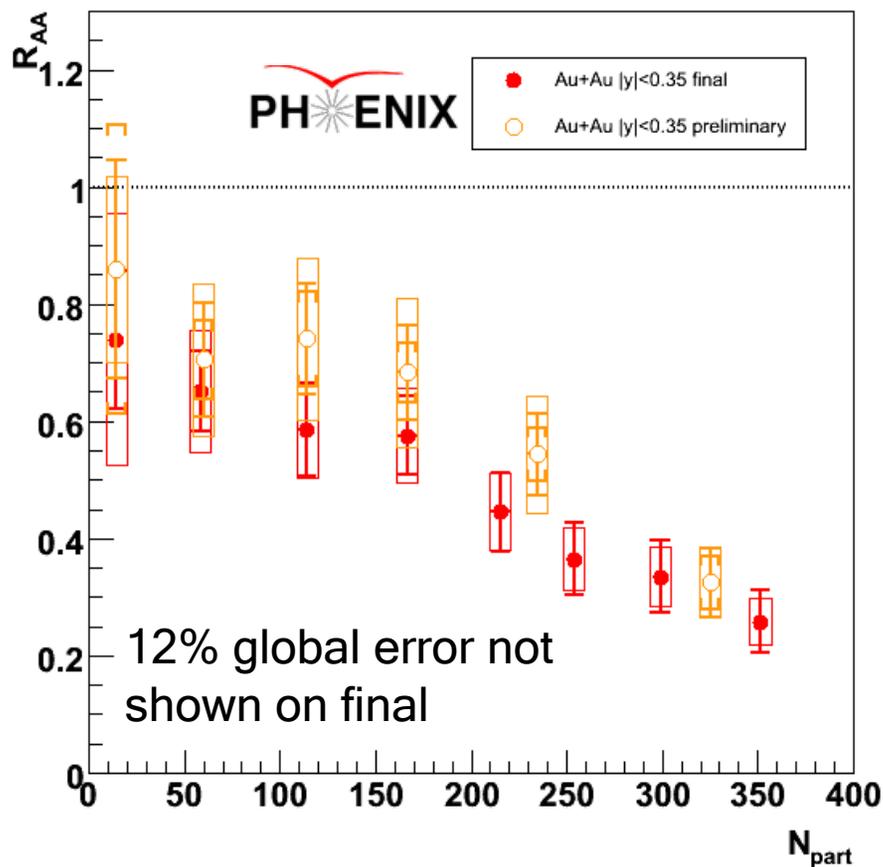
12 Countries; 58 Institutions; 480 Participants*

- USA** Abilene Christian University, Abilene, TX
Brookhaven National Laboratory, Upton, NY
University of California - Riverside, Riverside, CA
University of Colorado, Boulder, CO
Columbia University, Nevis Laboratories, Irvington, NY
Florida State University, Tallahassee, FL
Florida Technical University, Melbourne, FL
Georgia State University, Atlanta, GA
University of Illinois Urbana Champaign, Urbana-Champaign, IL
Iowa State University and Ames Laboratory, Ames, IA
Los Alamos National Laboratory, Los Alamos, NM
Lawrence Livermore National Laboratory, Livermore, CA
University of New Mexico, Albuquerque, NM
New Mexico State University, Las Cruces, NM
Dept. of Chemistry, Stony Brook Univ., Stony Brook, NY
Dept. Phys. and Astronomy, Stony Brook Univ., Stony Brook, NY
Oak Ridge National Laboratory, Oak Ridge, TN
University of Tennessee, Knoxville, TN
Vanderbilt University, Nashville, TN

***as of January 2004**

BONUS SLIDES

Preliminary vs Final

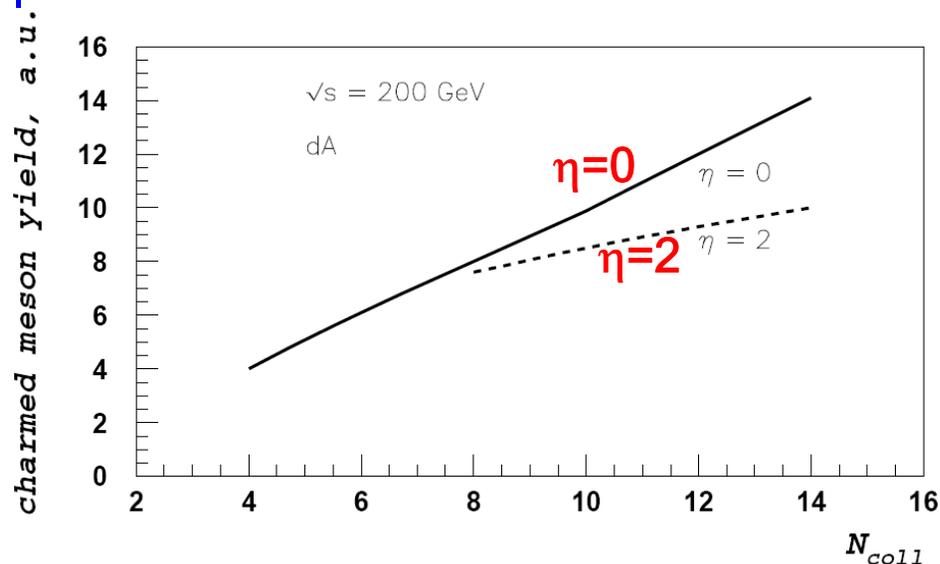


Careful subtraction of other contributions in the J/Ψ mass range lowered yields. These contributions were part of the large systematics in preliminary results.

Open charm production in the CGC model

hep-ph/0402298

Suppression below binary scaling at forward rapidity (small-x) in d+Au



Further suppression at forward rapidity in Au+Au

